INFORMATION PROCESSING METHOD
AND IMAGE REPRODUCTION APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a method and an apparatus which set, in a virtual space which is constructed based on an actually taken image, a position of an annotation to be displayed on the actually taken image.

Related Background Art

An attempt at taking (or shooting) a real space by a camera mounted on a vehicle (or a movable body), and representing the taken real space as a virtual space based on taken real image data by using a computer has been proposed. For example, Endo, Katayama, Tamura, Hirose, Watanabe, Tanikawa: "Computer Visualization Of Cybercities Using Vehicle-Mounted Cameras", Society Conference of IEICE (Institute of Electronics, Information and Communication Engineers), PA-3-4, pages 276-277, 1997, or Endo, Katayama, Tamura, Hirose, Watanabe, Tanikawa: Building Image-Based Cybercities By Using Vehicle-Mounted Cameras (2) -Generation Of Wide-Range Virtual Environment By Using Photo-Realistic Images-, Proc. of the Virtual Reality Society of Japan, Volume 2, pages 67-70 (1997.9) should be referred.

Incidentally, as a method of representing a taken real space as a virtual space based on data representing an actually taken image (hereinafter called actually taken image data), there is a method

5 of reproducing a geometrical model of the real space from the actually taken image data and representing the reproduced model in conventional CG (Computer Graphics) technique. However, in this case, there are limits in accuracy of the model and truth to

10 nature of the model. On one hand, IBR (Image-Based Rendering) technique of representing a virtual space by using the actually taken image without reproducing any geometrical model attracts attention in recent years. Here, because the IBR technique is based on

15 the actually taken image, a realistic virtual space can be represented. Besides, although vast times and efforts are necessary to form the geometrical model which covers a vast space such as city and town, such time and effect are unnecessary in the IBR technique

20 because any geometrical model is not reproduced.

To structure a virtual space which enables walk-through by using the IBR technique, it is necessary to generate and present an image according to the position of an experiencing person (also cited

25 as an observer hereinafter) in the virtual space. For that purpose, in a system of this kind, each image frame of the actually taken image data is

correlated with the position within the virtual space
and stored in advance, the corresponding image frame
is obtained based on the position and sight line
direction of the experiencing person in the virtual
5   space, and the obtained image frame is reproduced.

        Incidentally, in order to enable the
experiencing person to see a desired direction at
each viewpoint position during the walk-through
operation within the virtual space, the image frame
10   corresponding to each viewpoint position is stored in
advance as a panoramic image which covers the range
wider than an angle of view at a time when the image
at the viewpoint position in question is reproduced.
That is, when the image in question is reproduced,
15   the stored panoramic image is read based on the
viewpoint position of the experiencing person within
the virtual space, a partial image is cut out from
the read panoramic image on the basis of the sight
line direction of the observer, and the cut-out image
20   is then displayed. When the trail of the viewpoint
position within the virtual space is the same as the
trail of the vehicle on which the camera is mounted,
the observer feels as if the observer oneself takes
the vehicle and runs.

25   Moreover, by synthesizing an annotation such as
a name or the like of, e.g., a building to the
building in question included in the image and

displaying the synthesized annotation together with the image of the building in question, it is possible to provide more expressive information to the observer. Furthermore, by displaying such an

5 annotation, a marker or a sign which is obscure because the actually taken image is dark can be clearly known and grasped by the observer.

When the virtual space is described and represented by using the geometrical model, the

10 annotation can be synthesized and displayed at a desired position on the image. On one hand, when the virtual space is constructed in the IBR technique in which any geometrical model is not used, it is necessary to determine the display position of the

15 annotation in regard to each image.

However, conventionally, when the annotation is synthesized and displayed in the above virtual space which has been constructed in the IBR technique, it is necessary for the user to manually determine the

20 annotation display position in regard to each image, whereby it takes a lot of trouble with working in determining the annotation display position when there are a large number of images.

25 SUMMARY OF THE INVENTION

The present invention has been made in consideration of such a conventional problem, and an

object thereof is to simplify an operation for determining an annotation display position.

In order to achieve the above object, the present invention is characterized by an information processing method comprising: a viewpoint position/sight line direction determination step of determining a viewpoint position and a sight line direction on a map; an annotation display position determination step of determining an annotation display position of an object, from the position of the object in question on the map determined based on observation directions of the object in question in plural panoramic images, the viewpoint position, and the sight line direction; and a synthesis step of synthesizing an annotation image to the annotation display position on an actually taken image corresponding to the viewpoint position.

Moreover, the present invention is characterized by an information processing method, used in an image reproduction apparatus for achieving walk-through in a virtual space represented by using an actually taken image, of synthesizing an annotation image to the actually taken image, the method comprising the steps of: setting an annotation display position in each of the plural actually taken images; calculating an annotation display position to another actually taken image located between the

plural actually taken images, by using the annotation

display positions respectively set in the plural

actually taken images; and synthesizing the

annotation image to the actually taken image on the

5   basis of the calculated annotation display position.

Other features and advantages of the present

invention will be apparent from the following

description taken in conjunction with the

accompanying drawings, in which like reference

10   characters designate the same or similar parts

throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing the

15   functional structure of a walk-through system

according to the embodiment of the present invention;

Fig. 2 is a block diagram showing the hardware

structure of an image reproduction apparatus 1

according to the embodiment of the present invention;

20   Fig. 3 is a diagram for explaining a

representation method of a virtual space according to

the embodiment of the present invention;

Fig. 4 is a diagram showing an example of

attributes of section points and routes;

25   Fig. 5 is a diagram for explaining

correspondence between a panoramic image and a

direction of the route;

Fig. 6 is a diagram for explaining an annotation display position determination method in an annotation display position determination unit 50;

Fig. 7 is a flow chart for explaining an operation of the annotation display position determination unit 50;

Fig. 8 is a diagram for explaining an annotation synthesis process by an image reproduction control unit 40;

Fig. 9 is a diagram for explaining a method of determining an object position based on two panoramic images;

Fig. 10 is a flow chart for explaining a procedure to determine the position of each object on a map based on the two panoramic images;

Fig. 11 is a diagram showing a GUI (graphical user interface) 1000 for determining the object position;

Fig. 12 is a diagram for explaining a method of determining the object position on the GUI 1000;

Fig. 13 is a diagram showing a map on which an object to which an annotation is intended to be displayed, section points, and routes are disposed;

Fig. 14 is a diagram showing an example of attributes of the object to which the annotation is displayed;

Fig. 15 is a diagram showing a GUI 2000 for

setting an annotation display position in units of panoramic image;

Fig. 16 is a diagram for explaining a method of determining the annotation display position in units of panoramic image on the GUI 2000;

Fig. 17 is a diagram showing attributes of an object to which an annotation is intended to be displayed, according to the third embodiment;

Fig. 18 is a flow chart for explaining a procedure to determine an annotation display position in units of panoramic image, according to the third embodiment;

Fig. 19 is a flow chart for explaining the procedure to determine the annotation display position in units of panoramic image, according to the third embodiment;

Fig. 20 is a flow chart for explaining a procedure to determine an annotation display position for a certain object, in the annotation display position determination unit 50;

Fig. 21 is a diagram for explaining a method of determining an annotation display position according to the fourth embodiment;

Figs. 22A, 22B and 22C are diagrams for explaining relations of object observation directions $\theta 1$ and $\theta 2$ from respective panoramic images at two points, and an object observation direction θi from

the panoramic image on a route located between the two points; and

Figs. 23A, 23B, 23C, 23D, 23E, 23F and 23G are diagrams for explaining respective relations of frame

5 numbers and annotation display positions, based on the object observation directions $\theta1$ and $\theta2$.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the preferred embodiments of the

10 present invention will be explained with reference to the attached drawings.

(First Embodiment)

Initially, a walk-through system in a virtual space according to the first embodiment of the

15 present invention will be explained. In the present embodiment, panoramic image data is generated from actually taken image data obtained by plural cameras (or shooting devices) mounted on a vehicle such as an automobile or the like, the generated panoramic image

20 data is correlated with positions on a map corresponding to respective positions in a real space, and the correlated data are together stored. Then, a display image is generated based on the stored panoramic image data in accordance with a viewpoint

25 position (i.e., the position on the map) and a sight line direction of an experiencing person (or an observer), thereby achieving walk-through in the

virtual space.

Fig. 1 is a block diagram showing the functional structure of the walk-through system according to the present embodiment. An image reproduction apparatus 1 which constitutes the walk-through system is equipped with an operation unit 10, a viewpoint position/sight line direction determination unit 20, a map data storage unit 30, an image reproduction control unit 40, an annotation display position determination unit 50, an annotation data storage unit 60, an image data storage unit 70, and a display unit 80.

Fig. 2 is a block diagram showing the hardware structure of the image reproduction apparatus 1 according to the present embodiment. Here, it should be noted that the hardware structure shown in Fig. 2 is equivalent to that of an ordinary personal computer. In Fig. 2, a disk 105 acts as the image data storage unit 70, and also acts as the map data storage unit 30 and the annotation data storage unit 60.

A CPU 101 functions as the viewpoint position/sight line direction determination unit 20, the image reproduction control unit 40 and the annotation display position determination unit 50 by executing programs stored in the disk 105, a ROM 106 and/or an external memory (not shown).

Moreover, the CPU 101 issues various display
instructions to a CRTC (cathode ray tube controller)
102, whereby desired display is achieved on a CRT 104
by the CRTC 102 and a frame buffer 103. Here,

5   although the CRTC 102 and the CRT 104 are shown
respectively as a display controller and a display in
Fig. 2, the present invention is not limited to this.
That is, instead of the CRT, an LCD (liquid crystal
display) or the like can be of course used as the

10   display. Incidentally, the CRTC 102, the frame
buffer 103 and the CRT 104 together act as the
display unit 80. Besides, a RAM 107 is provided as a
working memory for the CPU 101 and the like.

A mouse 108, a keyboard 109 and a joystick 110

15   which are used by a user to input various data and
information to the image reproduction apparatus 1
together act as the operation unit 10.

Next, a schematic operation of the image
reproduction apparatus 1 in the walk-through system

20   according to the present embodiment will be explained.

The operation unit 10 which is equipped with
the mouse, the keyboard, the joystick and the like is
used to generate a movement parameter of the
viewpoint position and a rotation parameter of the

25   sight light direction. In the present embodiment,
although the joystick 110 is used to control the
viewpoint position and the sight line direction,

another input device such as a game controller or the like may be used. Incidentally, the inclination angle and the rotation angle of the joystick 110 can be controlled independently. In the present

5   embodiment, the operation to incline the joystick 110 corresponds to the movement of the viewpoint position in the virtual space, and the operation to rotate the joystick 110 rightward and leftward corresponds to the rotation of the sight line direction.

10   Incidentally, the map data storage unit 30 stores therein two-dimensional map image data.

      Moreover, the viewpoint position/sight line direction determination unit 20 determines the viewpoint position and the sight line direction of

15   the observer on the map image represented by the two-dimensional map image data stored in the map data storage unit 30, on the basis of the movement parameter and the rotation parameter input through the operation unit 10.

20   Furthermore, the image data storage unit 70 stores therein the panoramic image data corresponding to each position on the map. Here, it should be noted that the image data storage unit 70 need not exist as a local device of the image reproduction

25   apparatus 1. That is, it is possible to provide the image data storage unit 70 on a network, and thus read the image data from the image data storage unit

70 through the network.

The image reproduction control unit 40 receives the data concerning the viewpoint position and the sight line direction of the observer on the map from

5   the viewpoint position/sight line direction determination unit 20, and then reads the image data corresponding to the view point position from the image data storage unit 70 based on the received data. Incidentally, in the present embodiment, to correlate

10   the viewpoint position on the map with the image data, the necessary data have the following data storage formats.

That is, it is assumed that the movement of the observer is limited only on a taking (shooting) route,

15   the route is partitioned by section points such as an intersecting point (diverging point), a corner and the like, and the route is represented as the section points and the route located between the two section points. The section points are set on the two-

20   dimensional image, and the route is the line segment located between the section points. Then, an ID (identification) is added to each of the section points and the routes, the panoramic image taken at the position in the real space is assigned to the

25   corresponding section point, and the panoramic image group between the panoramic images respectively assigned to the section points of both the ends of

the route is assigned to the route in question. Fig.
3 shows such an aspect. That is, in Fig. 3, the ID
of R1 is given to the line segment (route) located
between the section point of which the ID is C1 and
5 the section point of which the ID is C2. Then, in a
case where the panoramic images respectively
corresponding to the section points C1 and C2 are
specified based on GPS (Global Positioning System)
data or the like, the panoramic image of which the
10 frame number is n is assigned to the section point C1,
and the panoramic image of which the frame number is
(n + m) is assigned to the section point C2. After
the panoramic images were assigned to the respective
section points, the panoramic image group including
15 the panoramic images of which the frame numbers are
(n + 1) to (n + m - 1) is automatically assigned to
the route R1. Similarly, the respective panoramic
image groups are assigned to the routes R2 to R5
respectively.
20   Incidentally, as shown in Fig. 4, each of the
section points and the panoramic images has the two-
dimensional coordinates on the map as its attribute.
Here, although the two-dimensional coordinates on the
map are generally calculated from the latitude and
25 longitude data obtained based on the GPS data, the
two-dimensional coordinates may be obtained from
image information through a computer vision.

Moreover, it is possible to obtain the two-
dimensional coordinates of only the section points at
both the ends of the route based on the latitude and
longitude data, and it is further obtain the two-

5   dimensional coordinates of the panoramic images on
the route between these section points through an
interpolation operation.

      The image reproduction control unit 40 gives
the viewpoint position on the map to the annotation

10   display position determination unit 50. Then, the
annotation display position determination unit 50
determines the display position of the annotation
based on the given viewpoint position information,
and gives the determined annotation display position

15   to the image reproduction control unit 40. How to
determine the annotation display position will be
described later. After then, the image reproduction
control unit 40 cuts out the panoramic image
according to the angle of view displayed on the

20   display unit 80, performs projection conversion to
the cut-out panoramic image, synthesizes the
annotation image to the converted panoramic image in
accordance with the annotation display position, and
then generates the image to be displayed on the

25   display unit 80.

      Subsequently, the display unit 80 displays the
image generated by the image reproduction control

unit 40.

Next, the operation of the annotation display
position determination unit 50 will be explained in
detail. In the present embodiment, on the route

5   located between the section points as shown in Fig. 5,
it is assumed that the front direction of the
panoramic image is in parallel with the direction of
the route in question, i.e., the camera forwarding
direction in the image taking or shooting.

10   Fig. 6 is a diagram for explaining an
annotation display position determination method to
be performed by the annotation display position
determination unit 50. For simplicity, it is assumed
that the section point C1 is the origin of an xy

15   plane, and the section point C2 is set on the x axis
of this plane (that is, the route R1 constitutes a
part of the x axis).

In Fig. 6, the coordinates of the section point
C1, the section point C2 and a building (object) A to

20   which the respective annotations are intended to be
displayed on the map are respectively (0, 0), (x2, 0)
and (xo, yo). Moreover, in the panoramic image
corresponding to the section point C1, the horizontal
position (i.e., position in horizontal direction) at

25   which the annotation of the building A is displayed
is represented in a relative angle $\theta 1$ (radian) from
the front direction of the panoramic image, as

follows.

$$\theta_1 = \begin{cases} \arctan(yo/xo) & (xo \neq 0) \\ \pi/2 & (xo = 0, \ yo > 0) \\ -\pi/2 & (xo = 0, \ yo < 0) \end{cases}$$

5   Furthermore, in the panoramic image corresponding to the section point C2, the horizontal position at which the annotation of the building A is displayed is represented in a relative angle θ_2 (radian) from the front direction of the panoramic

10   image, as follows.

$$\theta_2 = \begin{cases} \arctan\{yo/(xo-x2)\} & (xo \neq x2) \\ \pi/2 & (xo = x2, \ yo > 0) \\ -\pi/2 & (xo = x2, \ yo < 0) \end{cases}$$

Similarly, in the panoramic image corresponding

15   to the point (x, 0) on the route R1, the horizontal position at which the annotation of the building A is displayed is represented in a relative angle θ (radian) from the front direction of the panoramic image, as follows.

20   $$\theta = \begin{cases} \arctan\{yo/(xo-x)\} & (xo \neq x) \\ \pi/2 & (xo = x, \ yo > 0) \\ -\pi/2 & (xo = x, \ yo < 0) \end{cases}$$

The annotation display position determination unit 50 determines the horizontal positions at which

25   the annotations are displayed, in accordance with the above formulae. Fig. 7 is a flow chart for explaining the operation of the annotation display

position determination unit 50. In Fig. 7, in a step

S101, new viewpoint information (i.e., the viewpoint

position and the sight line direction) is first

obtained. Then, it is judged in a step S102 whether

5   or not the route determined based on the new

viewpoint information obtained in the step S101 is

the same as the route in the previous frame. When it

is judged that the route determined based on the new

viewpoint information is the same as the route in the

10   previous frame, the flow advances to a step S105. On

the contrary, when it is judged in the step S102 that

the route determined based on the new viewpoint

information is a new route different from the route

in the previous frame, the flow advances to a step

15   S103. In the step S103, the object to which the

annotation is displayed is determined on the route in

question. In the present embodiment, it should be

noted that the annotations can be respectively

displayed to the plural objects. After the object to

20   which the annotation is displayed was determined in

the step S103, the flow advances to a step S104. In

the step S104, one of the section points at both the

ends of the route in question is set as the origin of

the xy plane, the coordinate axis is rotated so that

25   the route in question coincides with the x axis, and

the relative positions of all the objects to which

the annotations are respectively displayed are

calculated. Next, in the step S105, an annotation display position θ (i.e., a relative angle from the front direction of the panoramic image) in the panoramic image corresponding to the viewpoint

5   position in question is obtained by the above formula, in regard to each of all the objects to which the annotations are respectively displayed. After then, it is judged in a step S106 whether or not to end the operation. When the operation should be continued,

10   the flow returns to the step S101 to again obtain new viewpoint information.

Fig. 8 is a diagram for explaining an annotation synthesis process by the image reproduction control unit 40. When the annotation

15   display position θ is determined by the annotation display position determination unit 50, the image reproduction control unit 40 cuts out the panoramic image according to the sight line direction and an angle of view α. Then, the annotation image read

20   from the annotation data storage unit 60 is synthesized on the cut-out panoramic image, whereby the display image is finally generated. Here, it should be noted that clinographic conversion for converting the panoramic image into a perspective

25   projection image is performed only to the panoramic image.

As described above, according to the first

embodiment, the annotation display position is determined based on the coordinates of the object position to which the annotation is intended to be displayed and the viewpoint position of the observer

5 on the two-dimensional map, whereby it is possible to achieve saving of work and time when the annotation display positions are determined to a large number of images.

(Second Embodiment)

10 In the above first embodiment, the annotation display position is determined based on the coordinates, on the map, of the object position to which the annotation is intended to be displayed and the viewpoint position of the observer. On one hand,

15 in the second embodiment, the position of an object on the map is determined based on the observation directions of that object in two panoramic images, whereby an annotation can be displayed at an appropriate position even if accuracy of the

20 coordinates of the object position and the sight line direction on the map is low.

Fig. 9 is a diagram for explaining a method of determining the object position based on the two panoramic images. In the present embodiment, the

25 position of the object on the map is determined based on the coordinates of the viewpoint position on the map, and moreover the position of the object on the

map is determined in regard to each route.
Incidentally, when the annotation display position is
calculated, the position of the object on the map
determined on the route where the viewpoint position

5   exists is used. In Fig. 9, for simplicity, it is
assumed that a section point C1 is the origin of the
xy plane, and a section point C2 is set on the x axis
of this plane (that is, a route R1 constitutes a part
of the x axis). Moreover, the coordinates of the

10 section points C1 and C2 are (0, 0) and (x2, 0)
respectively, and the front direction of the
panoramic image on the route R1 always corresponds to
the positive direction of the x axis.

When the observation direction (i.e., the

15 relative direction from the front direction) from the
section point C1 of an object (a building) A to which
the annotation is intended to be displayed is $\theta 1$ and
the observation direction from the section point C2
is $\theta 2$, the coordinates (xo, yo) of the object on the

20 map can be obtained from following formulae.

$$x0 = \begin{cases} 0 & (\theta 1 = \pi/2, -\pi/2) \\ x2 & (\theta 2 = \pi/2, -\pi/2) \\ x2\tan\theta 2/(\tan\theta 2 - \tan\theta 1) & (\text{other}) \end{cases}$$

$$y0 = \begin{cases} -x2\tan\theta 2 & (\theta 1 = \pi/2, -\pi/2) \\ x2\tan\theta 1 & (\theta 2 = \pi/2, -\pi/2) \\ x2\tan\theta 1\tan\theta 2/(\tan\theta 2 - \tan\theta 1) & (\text{other}) \end{cases}$$

25

Fig. 10 is a flow chart for explaining a

procedure to determine the position of the object on
the map based on the two panoramic images. Initially,
in a step S201, the object to which the annotation is
intended to be displayed is determined. Next, it is

5   judged in a step S202 whether or not the object
position determination ends on all the routes to
which the annotation of the object in question is
displayed. When it is judged that the object
position determination does not end on all the routes,

10   the flow advances to a step S203 to determine the
route to which the object position determination
should be performed. Then, in a step S204, the
object position on that route is calculated by the
above formulae. On the contrary, when it is judged

15   in the step S202 that the object position
determination ends on all the routes, the flow
advances to a step S205. Then, it is judged in the
step S205 whether or not the position determination
ends to all the objects to which the annotations are

20   intended to be displayed. When it is judged that the
position determination ends to all the objects, the
position determination ends. On the contrary, when
it is judged that the position determination does not
end to all the objects, the flow returns to the step

25   S201 to determine the next object.

Fig. 11 is a diagram showing a GUI 1000 for
determining the object position in the present

embodiment. The GUI 1000 includes a map display window 1010 for displaying a two-dimensional map image, panoramic image display windows 1020 and 1021 for displaying panoramic images corresponding to the

5 section points at both the ends of the route selected on the map display window 1010, an object addition button 1030, an existing object button 1040, and an update button 1050.

When the position determination is performed to

10 a new object to which any position determination is not yet performed, the object addition button 1030 is clicked by a mouse. On one hand, when the position of the object to which the position determination has been performed is corrected, the existing object

15 button 1040 is clicked by the mouse to select the desired object from the list of the objects to be displayed.

The map display window 1010 displays the two-dimensional map image on which the section points and

20 the routes are displayed. When the user clicks by the mouse the route to which the object position is intended to be determined, the panoramic images respectively corresponding to the section points at both the ends of the selected route are displayed

25 respectively on the panoramic image display windows 1020 and 1021.

Incidentally, it should be noted that the two

typical panoramic images may not be the panoramic

images respectively corresponding to the section

points at both the ends of the route. That is, the

two typical panoramic images may be panoramic images

5 at independent positions respectively designated on

the map by the user. For example, panoramic images

at the positions of the section points on the

different routes may be used.

Fig. 12 is a diagram for explaining a method of

10 determining the object position on the GUI 1000.

Here, a case where the position of the object

(building) A on the route R1 located between the

section points C1 and C2 is determined will be

explained. When the route R1 is clicked by the mouse,

15 the panoramic images corresponding to the respective

section points C1 and C2 are displayed on the

panoramic image display windows 1020 and 1021

respectively. First, on the panoramic image display

window 1020, when the direction in which the object A

20 is observed is clicked by the mouse, the straight

line parallel with the vertical direction of the

panoramic image passing the clicked point on the

panoramic image display window 1020 is drawn, and the

straight line indicting the clicked direction is

25 drawn on the map display window 1010. Then, the

similar operations are performed on the panoramic

image display window 1021 and the map display window

1010. As a result, on the map display window 1010,
the point at which the two straight lines intersect
is calculated and obtained as the position of the
object A on the route R1.

5   When the object position determination is
performed on all the routes to which the annotations
are intended to be displayed, the update button 1050
is depressed to store the obtained position data.

    Fig. 13 is a diagram showing a map on which an
10 object to which an annotation is intended to be
displayed, section points, and routes are disposed.
In Fig. 13, the object (building) A can be observed
from routes R1, R2, R3 and R4. Thus, when the
annotation of the object A is displayed on the routes
15 R1 and R2, the position of the object A on the route
R1 is calculated from the panoramic images
corresponding to the section points C1 and C2, and
the position of the object A on the route R2 is
calculated from the panoramic images corresponding to
20 the section points C2 and C3. Fig. 14 is a diagram
showing an example of attributes of the object to
which the annotation is displayed. That is, the
position coordinates (xo1, yo1) of the object on the
map are used when the annotation display position on
25 the route R1 is determined, and the position
coordinates (xo2, yo2) of the object on the map are
used when the annotation display position on the

route R2 is determined. Here, it should be noted
that the annotation image can be made different in
regard to each route.

Incidentally, the annotation image is given as
5   an image according to a JPEG (Joint Photographic
Experts Group) format in Fig. 14. However, another
image format may be of course used, and besides, a
moving image may be used as the annotation image.

Then, the annotation display position
10   determination unit 50 determines the position at
which the annotation is displayed, by using the
position coordinates of the object determined as
above on the map.

As described above, according to the second
15   embodiment, because the position of the object on the
map is determined based on the observation directions
of the object in question in the two panoramic images,
the annotation can be displayed at the appropriate
position even if accuracy of the coordinates of the
20   object position and the sight line direction on the
map is low.

Moreover, because the GUI is used, the position
of the object on the map can be easily determined.
(Third Embodiment)
25   In the above second embodiment, the position of
the object to which the annotation is intended to be
displayed on the map is determined based on the

observation directions of the object in question in the two panoramic images. On one hand, in the third embodiment, it enables to set an annotation display position in units of panoramic image and

5   preferentially use the set annotation display position, thereby performing annotation display at a more appropriate position.

Fig. 15 is a diagram showing a GUI 2000 for setting the annotation display position in units of

10 panoramic image. In Fig. 15, because a map display window 1010, panoramic image display windows 1020 and 1021, an object addition button 1030, an existing object button 1040 and an update button 1050 are respectively the same as those shown in Fig. 11, the

15 explanations thereof will be omitted. Besides, a panoramic image display window 1022 is used to display the panoramic image corresponding to an arbitrary point on the selected route.

Fig. 16 is a diagram for explaining a method of

20 determining the annotation display position in units of panoramic image on the GUI 2000. Here, after the position of the object (building) A was determined from the observation directions of the panoramic images at the two section points, when a point on the

25 route is clicked by the mouse, the panoramic image corresponding to the clicked point is displayed on the panoramic image display window 1022. At the same

time, the annotation display position determined from
the position of the object A is represented as the
straight line parallel with the vertical direction of
the panoramic image. When accuracy of the position

5 coordinates of the panoramic image on the map is low,
there is a fear that the represented annotation
display position is deviated or shifted from the
position at which the annotation is intended to be
actually displayed. Therefore, the appropriate

10 annotation display position is clicked on the
panoramic image display window 1022 to prevent this.
As described above, the annotation display position
determined in units of panoramic image is used in
preference to the annotation display position

15 determined from the position of the object on the map
and the viewpoint position in the annotation display
position determination unit 50.

Fig. 17 is a diagram showing attributes of the
object to which the annotation is intended to be

20 displayed, according to the third embodiment. That
is, in regard to the object (the building A), the
annotation display positions are set independently
for the two panoramic images (frame numbers n and m)
on the route R1. The independently set annotation

25 display positions are described as relative angles θn
and θm from the front direction of the panoramic
image.

Fig. 18 is a flow chart for explaining a procedure to determine the annotation display position in units of panoramic image, according to the third embodiment. In Fig. 18, because the

5 processes in steps S201 to S205 are respectively the same as those shown in Fig. 10, the explanations thereof will be omitted. Then, in Fig. 19, when it is judged in a step S301 not to determine the annotation display position in units of panoramic

10 image, the flow returns to the step S202 (Fig. 18). On the contrary, when it is judged to determine the annotation display position in units of panoramic image, the flow advances to a step S302 to select and determine the panoramic image to which the annotation

15 display position is determined. Next, in a step S303, the annotation display position is set in the panoramic image in question. After then, it is judged in a step S304 whether or not to end the operation. When the annotation display position is

20 determined to another panoramic image, the flow returns to the step S302.

Fig. 20 is a flow chart for explaining a procedure to determine the annotation display position for a certain object, in the annotation

25 display position determination unit 50. First, when it is judged in a step S311 that the annotation display position for the certain object has been set

in the panoramic image corresponding to the viewpoint

position, the set annotation display position is used

as it is. On the contrary, when it is judged that

the annotation display position for the certain

5   object is not set, the annotation display position is

determined from the object position and the viewpoint

position in a step S312, and then the determined

annotation display position is used. After then, the

annotation display position is determined in a step

10   S313, and the operation ends.

As described above, according to the third

embodiment, the annotation display position can be

set in units of panoramic image, and the set

annotation display position can be preferably used,

15   whereby the annotation display can be performed at

the more appropriate position.

Moreover, the GUI is used, whereby the

annotation display position can be easily set in

units of panoramic image.

20   (Fourth Embodiment)

In the above first to third embodiments, the

annotation display position is determined based on

the observer's viewpoint position on the map and the

object position on the map. On one hand, in the

25   fourth embodiment, the annotation display position is

easily determined without using a position on the map.

Fig. 21 is a diagram for explaining a method of

determining the annotation display position according to the fourth embodiment. In Fig. 21, it is assumed that a route R1 beginning from a section point C1 and ending to a second point C2 is represented by the

5 straight line. Moreover, it is assumed that the front direction of a panoramic image corresponding to the section point C1, the front direction of a panoramic image corresponding to the section point C2, and the front directions of panoramic images included

10 in a group corresponding to the route R1 are all the same (i.e., the direction extending from the section point C1 to the section point C2). Furthermore, it is assumed that the panoramic image of which the frame number is n is related to the section point C1,

15 the panoramic image of which the frame number is $(n + m)$ $(m > 0)$ is related to the section point C2, and the panoramic images of which the frame numbers are $(n + 1)$ to $(n + m - 1)$ are related to the route R1.

When the annotation of a building (object) A

20 shown in Fig. 21 is displayed to the group of the panoramic images related to the route R1, observation angles $\theta 1$ and $\theta 2$ of the building A at the section points C1 and C2 of both the ends of the route R1 are first obtained. Here, the observation angles $\theta 1$ and

25 $\theta 2$ are obtained beforehand in a preprocess in regard to each route.

In the annotation display position

determination unit 50, when the observation

directions of the building A from the section points

C1 and C2 are respectively given by the observation

angles $\theta 1$ and $\theta 2$, an annotation display position

5   (angle) θi of the building A in the panoramic image

of a frame number $(n + i)$ $(i > 0)$ on the route R1 is

obtained by linear interpolation, as follows.

$$\theta i = (\theta 2 - \theta 1)/m \times i + \theta i$$

As described above, according to the fourth

10   embodiment, the linear interpolation is performed to

the object observation directions of the panoramic

images at the two points, whereby the annotation

display position can be easily determined to the

group of the panoramic images related to the route

15   located between the two points. Moreover, the linear

interpolation is used to obtain the annotation

display position, whereby an amount of the

calculation can be reduced.

(Fifth Embodiment)

20   In the above fourth embodiment, the annotation

display position is obtained by performing the linear

interpolation to the object observation directions of

the panoramic images at the two points. On one hand,

according to the fifth embodiment, the annotation

25   display position is obtained more precisely by

performing non-linear interpolation.

Figs. 22A, 22B and 22C are diagrams for

explaining the relations of the object observation directions (angles) $\theta 1$, $\theta 2$ and θi shown in Fig. 21. In each of Figs. 22A, 22B and 22C, the horizontal axis indicates frame numbers, and the vertical axis indicates object observation directions. Moreover, the range of the object observation direction $\theta 1$ is limited to $0 \leq \theta 1 \leq \pi$, and the range of the object observation direction $\theta 2$ is limited to $0 \leq \theta 2 \leq \pi$. Furthermore, it is assumed that the intervals of the frame taking positions on the route R1 are all equal. Here, Fig. 22A shows the object observation directions from the respective frames on the route R1 in case of $\pi/2 \leq \theta 1 \leq \pi$ and $\pi/2 \leq \theta 2 \leq \pi$. Fig. 22B shows the object observation directions from the respective frames on the route R1 in case of $0 \leq \theta 1 \leq \pi/2$ and $\pi/2 \leq \theta 2 \leq \pi$. Fig. 22C shows the object observation directions from the respective frames on the route R1 in case of $0 \leq \theta 1 \leq \pi/2$ and $0 \leq \theta 2 \leq \pi/2$. As shown in Figs. 22A to 22C, when it is assumed that the panoramic images are taken at the same intervals, the object observation directions do not change linearly but change non-linearly. Incidentally, each of the non-linear curves shown in Figs. 22A to 22C corresponds to an arctangent function obtained by the object observation directions (angles) $\theta 1$ and $\theta 2$.

When the annotation display position of the object is determined by the annotation display

position determination unit 50, the annotation

display position (angle) θ_i is determined by using,

as an interpolation function, the arctangent function

obtained from the object observation directions

5   (angles) θ_1 and θ_2 from the two section points at

both the ends of the route. Incidentally, to reduce

an amount of calculation, a linearly approximated

function of the arctangent function may be uses as

the interpolation function.

10   Moreover, to reduce an amount of calculation by

the arctangent function, a table which indicates the

relations between frame numbers and annotation

display positions may be prepared beforehand. As

shown in Figs. 23A, 23B, 23C, 23D, 23E, 23F and 23G,

15   in case of $-\pi < \theta_1 \leq \pi$ and $-\pi < \theta_2 \leq \pi$, the relations

between the frame numbers and the annotation display

positions are classified into six kinds (or patterns)

of arctangent-function shapes in accordance with the

object observation directions θ_1 and θ_2. The

20   annotation display position determination unit 50

holds beforehand the correspondence table which

indicates six-pattern relations between the frame

numbers and the annotation display positions based on

representative values of the object observation

25   directions θ_1 and θ_2, judges to which of the six

patterns the target is closest on the basis of the

object observation directions θ_1 and θ_2 from the

section points at both the ends of the current route,
and refers to the value of the correspondence table
on the basis of the corresponding frame number. It
should be noted that it may be judged beforehand to
5   which of the six patterns the target is closest. The
correspondence table changes according to the number
of panoramic images related to the route. Here, the
correspondence table is formed beforehand with
sufficiently fine resolutions, and the scale thereof
10   is controlled according to the number of panoramic
images on the corresponding route, whereby the number
of correspondence tables is controlled. Incidentally,
although the six correspondence tables are provided
in the present embodiment, the number of
15. correspondence tables can be increased according to
the capacity of a RAM or the like. Moreover, in a
case where the small number of correspondence tables
are provided initially, when approximation cannot be
achieved by the current correspondence tables in view
20   of the actual annotation display positions, the
interpolation functions determined by using the
object observation directions from the section points
at the both ends of the route to which the displaying
is deviated or shifted are added as needed. By doing
25   so, the accuracy can be increased.

As described above, according to the fifth
embodiment, the interpolation is performed by using

the arctangent functions obtained based on the object observation directions from the panoramic images at the two points, the annotation display positions can be determined more accurately to the group of the

5   panoramic images related to the route located between the two points.

(Other Embodiments)

Although the panoramic images are used in the above embodiments, images other than the panoramic

10   image may be also used.

Moreover, to provide program codes of software for achieving the functions of the above embodiments through a network is included in the concept of the present invention.

15   In this case, the program codes themselves of software achieve the functions of the above embodiments, whereby the program codes themselves and a means for supplying the program codes to a computer constitute the present invention.

20   Moreover, it is to be understood that the present invention includes not only the case where the functions of the above embodiments are achieved when the computer executes the supplied program codes but also a case where the functions of the above

25   embodiments are achieved when the computer executes the supplied program codes in cooperation with an

operating system (OS) running on the computer, another application software or the like.

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the appended claims.